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REVIEW

Weight Reduction Interventions Using Digital Health for Employees with Obesity: A Systematic Review

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Purpose: This study aimed to systematically review the literature on randomized controlled trials on weight reduction interventions using digital health for employees with obesity.

Methods: All relevant articles published until September 2021 were systematically identified from six electronic databases: MEDLINE, EMBASE, CINAHL, PsycINFO, RISS, and KISS. Data selection and extraction were independently performed by three researchers. Methodological quality was assessed using the JBI Critical Appraisal Checklist for Randomized Controlled Trials. The results were narratively synthesized.

Results: Eleven studies were included in the systematic review. All studies had a low risk of bias. The settings and sample sizes of the included studies were different. The contents of the interventions included nutrition, physical activity, behavioral change, incentives, and motivation. Four studies were based on social cognitive theory. A total of ten studies delivered web-based intervention, while the other used tele-monitoring device. A wide range of intervention strategies was used including providing online resources, tele-counseling, and patient-tailored advice. As a result of the intervention, a total of seven studies showed a significant weight reduction in both the intervention and comparison groups, with significant differences between groups.

Conclusion: Until now, use of digital health in weight reduction interventions for employees with obesity has been conducted on a web-based. Various contents such as nutrition, physical activity and theories were explored. Further study is required using more diverse delivery methods such as mobile application, use of wearable devices.

Keywords: obesity, weight reduction, digital health, telemedicine, occupational groups

Introduction

The number of individuals affected by overweight and obese has increased. In 2016, according to the World Health Organization, more than 1.9 billion adults were overweight and over 650 million of these were obese.[1] Overweight and obesity are major risk factors for a number of chronic diseases, including diabetes and cardiovascular diseases such as heart disease and stroke.[2] These diseases result in over 4 million deaths each year, according to the global burden of disease.[3]

Among the increasing overweight and obese population, there has been conducted a lot of researches which focused on overweight and obesity of employees, especially. Many previous studies have emphasized the importance of intervention for employees with overweight or obesity because they have longer sick leaves and are at increased risk of work disability.[4–6] Numerous worksite interventions have been conducted to reduce the body weight and body mass index (BMI) of employees, including modification of diet and physical activity levels and behavioral therapy.[7,8] In addition, some of them demonstrated the effectiveness of interventions based on theories such as Social Cognitive Theory and the Transtheoretical Stages of Change Model.[9–12] These interventions not only brought physical and mental health improvements to employees, but also resulted in reduced sick leave and increased employee's productivity and output for workplaces.[13–15]

With the advancement of technology, the use of digital health in weight reduction interventions have several advantages, such as convenience, cost-effectiveness, and the ability to tailor interventions according to their needs.[16,17] Several systematic reviews have attempted to examine the potential of weight reduction interventions using digital health.[16,18–22] These previous reviews demonstrated that weight-reduction interventions using digital health showed greater weight reduction than face-to-face interventions in adults with overweight or obesity. In addition, the effectiveness of the use of digital health intervention in the workplace has already been proven. The previous review has reported that digital-only health interventions for employees in the workplace have a positive impact on health-related outcomes.[23] However, to our knowledge, no systematic review has been conducted on the development and implementation of weight-reduction interventions using digital health for employees with obesity.

This study aims to systematically review the literature on randomized controlled trials (RCT) of weight reduction interventions using digital health for employees with obesity to identify the characteristics of the literature including theoretical background, intervention contents, implementation approaches, and use of digital health, and to provide suggestions for future interventions through a comprehensive review.

Methods

This systematic review was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist.[24]

Search Strategy

All relevant articles were systematically identified from six electronic databases: MEDLINE, EMBASE, CINAHL, PsycINFO, RISS, and KISS. The search was conducted in October 2021 without conducting further manual searches. The timeframe for the analysis was restricted to September 2021. Based on the PICO model, the population was "employees with obesity", intervention was "weight reduction interventions using digital health", "weight reduction program using digital health", or "weight reduction management using digital health"; comparisons and outcomes were not set in this systematic review search keywords. The search terms were conducted using indexing terms, Medical Subject Heading Terms (MeSH terms), and free-text search terms Appendix 1.

Eligibility Criteria for Study Selection

The inclusion criteria were as follows: (a) adult employees affected by obesity or overweight in jobs; (b) interventions for weight reduction using digital health devices such as computers, tablets, personal digital assistants (PDAs), and smartphones; (d) measurement of participants' bodyweight or BMI; (e) original articles published in English or Korean; and (f) the study design was RCT.

Selection of Studies

A flowchart of the study selection process is presented in Figure 1. Duplicate studies were removed using bibliographical software and manual searches. Subsequently, the studies were screened by reading the title and abstract following the inclusion criteria. The entire texts of the screened studies were assessed at the end stage, and appropriate studies were selected. The selection process was independently performed by three researchers. Two researchers conducted screening for the half of included studies. The other researcher conducted screening for all included studies. The screening results were compared. Any disagreement between them was resolved through group discussion.

Methodological Quality Appraisal

Methodological quality was assessed using the JBI critical appraisal checklist for RCT.[25] The tool consisted of 13 items. Each item was answered as "Yes", "No", "Unclear", or "Not/Applicable". The overall scores were calculated as the proportion of "yes". The result of the quality appraisal was scored as i) ≤49% = high risk of bias and ii) above 50% = low risk of bias.[26,27] Four researchers independently performed the assessment, and a group discussion was conducted to reach agreement on the quality appraisal.
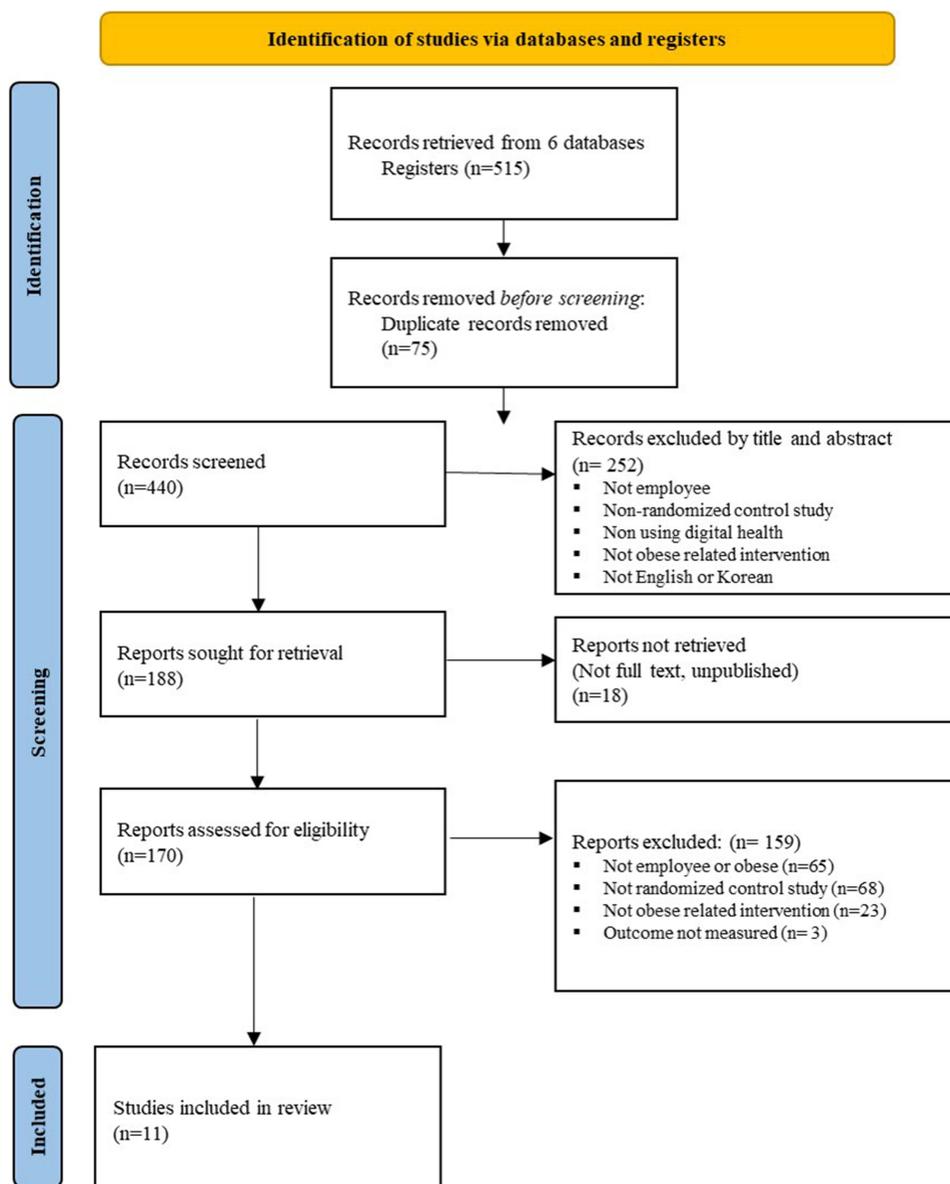
Identification of studies via databases and registers

Figure 1 PRISMA Flow Diagram for Systematic Review.
Notes: PRISMA figure adapted from Moher D, Liberati A, Altman D, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. Journal of clinical epidemiology. 2009;62(10). Creative Commons.[24]

Data Extraction and Synthesis

The data extracted for characteristics of the studies included the first author, publication year, country, population, characteristics of sample (sample size, age), characteristics of intervention (contents, theoretical background, intervention length, and follow-up), and major results (outcome variables, results). In addition, we summarized the use of digital health in these studies. These tables were thoroughly assessed by four reviewers through group discussion. A quality analysis was adopted rather than a meta-analysis because the studies included had differences in the types of digital health used for intervention, intervention length, and research outcomes.[28]

Results

Search Results

A total of 521 articles were initially retrieved from the databases and 449 articles were obtained after duplicate removal. After screening titles and abstracts, 188 full-text articles were retrieved. An additional 159 articles were

excluded because they did not meet the inclusion criteria. Eleven articles met the inclusion criteria and were used in this systematic review.

Quality Appraisal of Included Studies

The results of the risk of bias assessment for the 11 included studies are presented in Figure 2. All studies were scored as 'low risk of Bias'. As for the quality assessment by each item, item 6 "were outcomes assessors blind to treatment assignment?" were unclear or unable to blind in 9 studies. Item 3: "Were the treatment groups similar at baseline?", Item 11 "Were outcomes measured reliably?" and Item 12 "Was appropriate statistical analysis used?" were assured in all included studies.

Characteristics of the Included Studies

Table 1 presented characteristics of the included studies. A growing number of publications occurred within 10 years, with 81.8% (n = 9) published between 2012 and 2022. The United States had the largest number of publications (36.4%), followed by Germany (18.2%), and Japan (18.2%).

The settings of the studies were different, and included government, pharmaceutical companies, healthcare centers, and automobile manufacturing. The participants in the studies were employees with overweight or obese, 81.8% were those with obese and 18.2% were those with either overweight or obese. In the eight studies that reported the mean age of participants, the mean age of included participants was 43.5 years.[29–33,37–39] The sample sizes of the included studies ranged from 34 to 7743 in the intervention group and from 22 to 1001 in the control group.[32–34,38]

The intervention contents across the included studies consisted of nutrition, physical activity, behavioral change, incentives, and motivation. Except for Pressler and Knebel's study,[35] ten studies included nutrition contents related to nutrient information, health eating, health, recipes, and fluid intake. All studies included physical activity contents related to explanations of exercises, fitness videos, and consultations with fitness advisors. A total of seven studies[29,31–34,37,39] included behavioral change contents

Figure 2 Risk of Bias Results of the Included Studies.

Table 1 Characteristics of the Included Studies

Author (Year)	Country	Population	Interventions	Results
		• **Characteristics** • **Mean Age** • **Sample Size**	• **Contents** • **Theoretical Background** • **Intervention Length**	• **Outcome Variables** • **Follow Up** • **Major Results**
Abdi et al (2015)[29]	Iran	• Governmental Employees with obesity • Web = 42.5 years, Telephone = 41.1 years • IG: Web = 135, Telephone = 135, CG: 135	• Nutrition, Physical activity, Behavioral change, Incentive • Social cognitive theory • 6m	• BW, WC, BP, Physical activity, Nutrition • Baseline, 12m, 15m • A weight reduction of 1.92 in the telephone-assisted intervention groups ($p<0.001$) and 1.08 kg in the web-assisted intervention groups($p<0.001$)
Almeida et al (2015)[38]	USA	• Employees with obesity in multiple industries • 46.9 years • IG: 789, CG: 1001	• Nutrition, Physical activity, Incentive • Social cognitive theory • 12m	• BW, BMI, Physical activity behavior, Dietary behavior • Baseline, 18m • All groups reduced weight and BMI ($p<0.001$), but without significant difference between groups.
Balk-Moller et al (2017)[39]	Denmark	• Employees with obesity in Social Welfare Sector • 47 years • IG: 355, CG: 211	• Nutrition, Physical activity, Behavioral change • N/A • 16wk	• BW, WC, BMI, BP, Total cholesterol • Baseline, 16wk, 38wk • IG lost more weight than CG (-1.01 kg, $p=0.03$)
Carnie et al (2013)[30]	USA	• Female employees with overweight • 47 years • IG: 99, CG: 100	• Nutrition, Physical activity, Incentive • N/A • 6m	• BW, WC, HC, BMI, Glucose, Insulin, Lipid, Total fat mass, Percent truncal fat, Exercise performance, peak VO$_2$, Insulin sensitivity, Pedometer • Baseline, 3m, 6m • IG lost more weight than CG at 3 months (-2.2 ± 2.8 vs -1.0 ± 3.0 kg, $p<0.001$). Weight reduction at 6 months was significant in both IG and CG, but without significant difference between groups
Day et al (2019)[31]	USA	• Employees with overweight or obesity • 37.1 years • IG: 221, CG: 200	• Nutrition, Physical activity, Behavioral change • N/A • 6m	• BW, BMI, Intent to treat • Baseline, 6m • A weight reduction from 1.04 to 1.41 kg in IG, and an weight gain in CG
Kempf et al (2019)[32]	Germany	• Employees with obesity in Pharmaceutical company • 51 years • IG: 34, CG 1: 34, CG 2: 36	• Nutrition, Physical activity, Behavioral change, Motivation • N/A • 12m	• BW, BMI, WC, BP, Triglyceride, HbA1c, Fast blood glucose, Adiponectin, C-reactive protein, Eating behavior, Physical activity, Quality of life • Baseline, 3m, 6m, 9m, 12m, 36m • All groups reduced weight after 12 months (all $p<0.01$) and sustained it during the 36 months follow-up (all $p<0.01$), without significant difference between groups.

(Continued)

Table 1 (Continued).

Author (Year)	Country	Population	Interventions	Results
		• **Characteristics** • **Mean Age** • **Sample Size**	• **Contents** • **Theoretical Background** • **Intervention Length**	• **Outcome Variables** • **Follow Up** • **Major Results**
Ozaki et al (2018)[33]	Japan	• Employees with obesity in multiple industries • 34.2 years • IG: Standard = 24, Enhanced = 25, CG: 22	• Nutrition, Physical activity, Behavioral change • N/A • 12wk	• BW, WC, BMI, Physical activity, Energy intake, Diet History Questionnaire, Self-efficacy, Perceived health competence scale • Baseline, 12wk • Enhanced IG lost more weight than standard IG and CG ($p<0.001$), and standard IG lost more weight than CG ($p=0.033$)
Petersen et al (2008)[34]	USA	• Employees with obesity in multiple healthcare center • N/A • IG: 7743, CG 1: 128, CG 2: 188	• Nutrition, Physical activity, Behavioral change, Motivation • N/A • At least 18wk	• BW, BMI, Health risk behavior (Smoking, Physical inactivity, high stress, high cholesterol), Eating habit • Baseline, 6m, 12m • The percentage of participants in the normal weight category had increased from 27.0% to 29.8% ($p< 0.05$). Increased website usage was associated with increased weight reduction and stage of change improvements.
Pressler et al (2010)[35]	Germany	• Employees with obesity in Automobile Manufacturer • N/A(Median age 48 years) • IG: 84, CG: 56	• Physical activity • N/A • 12wk	• BW, WC, BMI, Body fat composition, BP, HDL, Triglycerides, FBG, peak VO_2, Peak ergometer performance (Pmax/Kg), Heart rate during ergometry, Acceptance of the intervention questionnaire • Baseline, 12wk • Weight reduction at 12 weeks was significant in both IG and CG, but without significant difference between groups
Sakane et al (2013)[36]	Japan	• Employees with obesity in multiple healthcare center • N/A • IG: Web+Visceral fat measurement = 88, Web = 95, CG: 68	• Nutrition, Physical activity • Social cognitive theory • 12wk	• BW, BMI, WC, Assessment of Lifestyle improvement • Baseline, 12wk • Reduction of weight, waist circumference, and BMI and improvements of health behaviors were the largest in Web and Visceral fat measurement group, with the significant differences between groups.
Van Wier et al (2012)[37]	Netherlands	• Employees with obesity in multiple industries • 43.3 years • IG: Phone = 462, Internet 464, CG: 460	• Nutrition, Physical activity, Behavioral change • Social cognitive theory • 6m	• BW, WC, Dietary intake, Physical activity • Baseline, 24m • Weight reduction at 24 months was significant in both IG and CG, but without significant difference between groups

Abbreviations: IG, intervention group; CG, comparison group; wk, week; m, month; BW, body weight; WC, waist circumference; BP, blood pressure; BMI, body mass index; HC, hip circumference; HDL, high-density lipoprotein; FBG, fasting blood glucose.

related to assessing dietary changes, physical activity changes, and personalized goal setting changes. Two studies[32,34] included motivation contents related to consultation or discussion with experts regarding barriers to change, encouragement, and emotional support. Two studies[30,38] provided incentives based on the percent of weight loss.

Four studies[29,36–38] were based on social cognitive theory. Interventions were conducted for an average of 23.8 weeks and follow-up was measured at a minimum of 3 months and maximum of 36 months from the baseline.

As a result of the intervention, all studies reported a statistically significant reduction in body weight after intervention. Among them, seven studies[29–31,33,34,36,39] showed significant differences between the intervention and comparison groups. A total of six studies[29,30,33,34,36,39] showed weight reduction after intervention in both the intervention and comparison groups, and the intervention group lost more weight than the comparison group. In Day et al[31] the intervention group showed a significant weight loss after intervention, but the comparison group significantly gained the weight. In the remaining four studies,[32,35,37,38] there was significant weight loss in both the intervention and comparison groups after intervention, but with no significant difference between the groups.

Use of Digital Health of the Included Studies

The use of digital health in the included studies is shown in Table 2. Except for the study by Kempf et al[32] conducted using a tele-monitoring device, all interventions in the included studies were web-based. Most included studies provided

Table 2 Use of Digital Health

Author (Year)	Delivering Method				Intervention Strategies				
	E-mail	Website	Mobile App	Tele-Monitoring Device	Tele-Counseling	Patient-Tailored Advice	Telemonitoring of Patient's Generated Health Related Data	Providing Online Resources	Online Social Support
Abdi et al (2015)[29]		√			√			√	√
Almeida et al (2015)[38]	√				√	√		√	
Balk-Moller et al (2017)[39]		√	√		√	√	√	√	√
Carnie et al (2013)[30]		√				√	√		
Day et al (2019)[31]		√			√	√	√	√	
Kempf et al (2019)[32]				√	√		√	√	
Ozaki et al (2018)[33]		√				√	√	√	√
Petersen et al (2008)[34]		√			√	√	√	√	√
Pressler et al (2010)[35]		√				√	√	√	
Sakane et al (2013)[36]		√			√	√		√	
Van Wier et al (2012)[37]		√			√	√		√	

online resources as intervention strategies. Ten studies[29,31–39] delivered online education on diet, nutrition, exercise, motivation, and behavioral changes. Nine studies[30,31,33–39] implemented programs focusing on patient-tailored advice such as "daily emails tailored to each participant", "personalized goal setting", "tailored remote group sessions", "personalized structured exercise schedules", and "self-selected healthy activities". Eight studies[29,31,32,34,36–39] delivered tele-counseling interventions. A personal counselor called, or e-mailed, and explained the goal of the program, and counseled them about weight reduction. Seven studies[30–35,39] monitored patients' health-related data, such as food intake, pulse rate, and heart rate. Online social support interventions were used in four studies.[29,33,34,39]

Discussion

A systematic review of weight reduction interventions using digital health for employees with obesity was conducted on 11 weight reduction interventions. We described the characteristics of selected studies, including study population (characteristics, mean age, and sample size), interventions (contents, theoretical background, and intervention length), and results (outcome variables, follow-up, and major results). The use of digital health, including delivery methods and intervention strategies, was also reviewed. All studies used body weight as the outcome measure. All studies reported a statistically significant reduction in body weight after intervention. Four studies[32,35,37,38] reported no significant differences between the intervention and comparison groups. All studies had a low risk of bias.

Most previous studies on employees with obesity have focused on interventions to encourage physical activity.[40–42] Our findings differ from those of previous interventions in that the interventions not only focused on physical activity, but also included nutrition, behavior change, and provision of incentives. This could be due to differences in the study populations included in this review. Most previous studies included sedentary employees; however, our study included employees of various occupations working in various workplaces.

Four studies[29,36–38] used social cognitive theory, which is one of the most common theories informing intervention design, while the remaining studies did not have a theoretical background. Our findings differ from those of a review of models that concluded that the theory of planned behavior and socio-ecological model was the most promising for obesity prevention, as none of our studies used those models.[43] This could be due to differences in aim: the previous review dealt with primary prevention, while our study dealt with secondary intervention, which is consistent with a previous study.[44] In addition, among the four studies based on social cognitive theory, two[37,38] were not significantly different between the intervention and comparison groups. In a previous systematic review of workplace health promotion programs,[44] other theories, such as the stages of change model and the transtheoretical model, were used and showed a significant reduction in BMI. However, it is not yet possible to conclude whether it is effective to develop and implement an intervention program using theories for employees with obesity, and it requires to be proven in future study.

Except for the study by Kempf et al[32] all studies included in this review used web-based weight reduction interventions rather than mobile app-based interventions. Many previous studies using mobile applications have been actively conducted within the last 10 years and have reported notable success in obesity control, weight reduction, physical activity increase, and quality of life improvement.[45–47] Considering that nine studies, except for two,[34,35] were published within 10 years, it can be seen that few mobile app-based interventions have been conducted on employees with obesity. This may be because the cost of the development of a mobile app-base intervention may be considered expensive for academic purposes. A mobile app makes employees engage in an intervention program any time at any place, so that it is useful in that employees can comfortably access it at worksites. Future research is required to perform well-designed RCT using mobile applications.

Diverse intervention strategies were used in most of the studies included in this review. However, the digital technologies used in the included studies were limited to counseling through telephone or e-mail and monitoring of the data entered by employees with obesity. With the advancement of technology, the intervention strategies of weight reduction interventions have been diversified. Use of video call have proven to be more effective as a means of health guidance than face to face.[48] In addition, it has been proven that the introduction of wearable device and mobile application is more effective for weight reduction in patients with overweight or obese than others.[49,50] Attempts should be made in future research to apply more up-to-date intervention strategies, such as performing an online video call or

automatically collecting multimodal data such as body weight and BMI from a digital scale or physical activity from a wearable device. These attempts could be effective and useful in the current healthcare environment and should be evaluated in future research.

This systematic review has some limitations. First, the review included only 11 studies published in peer-reviewed literature. It excluded gray literature and unpublished literature, which present potential publication bias. To integrate with the wider literature, it is required to utilize an agreed language such as BCT taxonomy in a future study.[51] Second, heterogeneous population and settings of included studies might reduce generalizability of the study and downgrade the overall strength of the evidence. In addition, only studies published in English were included in this review, with almost conducted in relatively advanced countries such as USA, Germany, and Japan. Therefore, the review is limited in the generalizability to other countries where other cultural factors associated with weight reduction intervention and use of digital health.

Conclusion

The results of this review have several important implications for future research in employees with obesity. The studies conducted so far have only been web-based even if digital health is used. In a future study, delivery methods and intervention strategies require to reflect the latest technology, such as the development of a mobile app-based intervention program, the use of video calls, wearable devices, and digital scales. In addition, weight reduction interventions for employees with obesity have been developed and applied using limited theory to date. It is necessary to verify whether the theory is effective in intervention targeting these groups.

Acknowledgments

Disclosure

The authors report no conflicts of interest in this work.

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